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LANDSAT APPLICATION OF REMOTE SENSING TO SHORELINE-FORM ANALYSIS

Contract No. NAS5-20999
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Quarterly Report for Period 12/2/75 to 3/2/76

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16. Abstract

Atlantic coast barrier-island shorelines are seldom straight, but rather sinuous in plan view. These shoreline curvatures range in size from cusps to capes. Significant relationships exist between shoreline dynamics and the orientation of shoreline segments with correlation coefficients exceeding .9.

Orientation of the shoreline segments of Assateague Island (55 km) was measured from Landsat II imagery enlarged to 1:250,000 and 1:80,000. Long-term trends in shoreline dynamics were established by mapping shoreline and storm-surge penetration changes from historical low altitude aerial photography spanning four decades.

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PREFACE

Objective

Our objective is to quantify relationships between shoreline form and coastal dynamics and to predict areas of vulnerability to shoreline erosion and storm surge penetration. We are developing data sets on changes in coastal geomorphology along the mid-Atlantic sedimentary coasts using three scales of imagery: Landsat enlarged to 1:250,000 and 1:80,000; high altitude aerial photography at 1:120,000; and low altitude aerial photography from 1:5,000 to 1:20,000.

Scope of Work

This report reviews the methods we used to collect historical data on changes in coastal geomorphology from aerial photography, and the methods we used to quantify shoreline form from Landsat imagery. We have established that there is a significant relationship between shoreline form (angular orientation) and coastal dynamics (erosion).

Conclusions

Regression analysis of the degree of association between coastal orientation and coastal erosion on Assateague Island shows that there is a positive correlation of greater than .9 at the 1 percent level of significance.

As the orientation of a straight-line segment of the Assateague coast approaches north-south, erosion rates and vulnerability to storm damage increase.

Through simple mechanical measurements, Landsat imagery can be used to define those sections of Assateague Island that will have the highest probability of storm damage.

Summary of Recommendations

Cape Hatteras data sets should be analyzed in order to compare the geomorphological organization of another major

barrier-island system with the results of our analysis of the Assateague Island data. Further studies should be extended to the New Jersey and/or Cape Lookout coastlines to determine the extent to which our initial results can be generalized. Field work should be undertaken during the summer months to gather site-specific data for additional comparative analysis. If the recent March storm does not prove to have been powerful enough to cause change along the coast of our study site, next year's storm season must be monitored so that our hypothesis regarding storm damage prediction can be tested. The current NASA project should be extended for two years in order to fulfill the above objectives.

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INTRODUCTION

During the period covered by this report, 12/2/75 to 3/2/76, refinements were made in our method of measuring coastal orientation with Landsat imagery. Various expressions of shoreline form were compared with historical coastal erosion data. Regression and correlation analyses were performed on this data with correlation co-efficients ranging from near zero to near 1.0 (abs. val.).

Slides and illustration boards that describe our work have been prepared for presentation to prospective users of Landsat imagery. Audiences have included state and federal park administrators on Assateague Island, U.S. Geological Survey and National Park Service officials in Washington, D.C., students at the University of Virginia, and coastal scientists at Louisiana State University.

In this report we review our method of data collection and present significant results relating shoreline form to shoreline dynamics.

ACCOMPLISHMENTS

During the period covered by this report (12/2/75 to 3/2/76), most of our efforts were spent in developing methods for measuring various expressions of shoreline form from Landsat imagery, and in analyzing relationships between shoreline form and coastal erosion with the aid of the computer. Our test site along the mid-Atlantic coast includes Assateague Island and Cape Hatteras (Figure 1). Shoreline form is expressed in terms of length and orientation of relatively straight-line segments within large arcs of the coast are measured from photography enlargements (1:250,000 to 1:80,000) of Landsat 70 mm negative transparencies of band 7. Expressions for coastal dynamics are the mean and standard deviation of rate of erosion over time as measured from historical low altitude aerial photography.

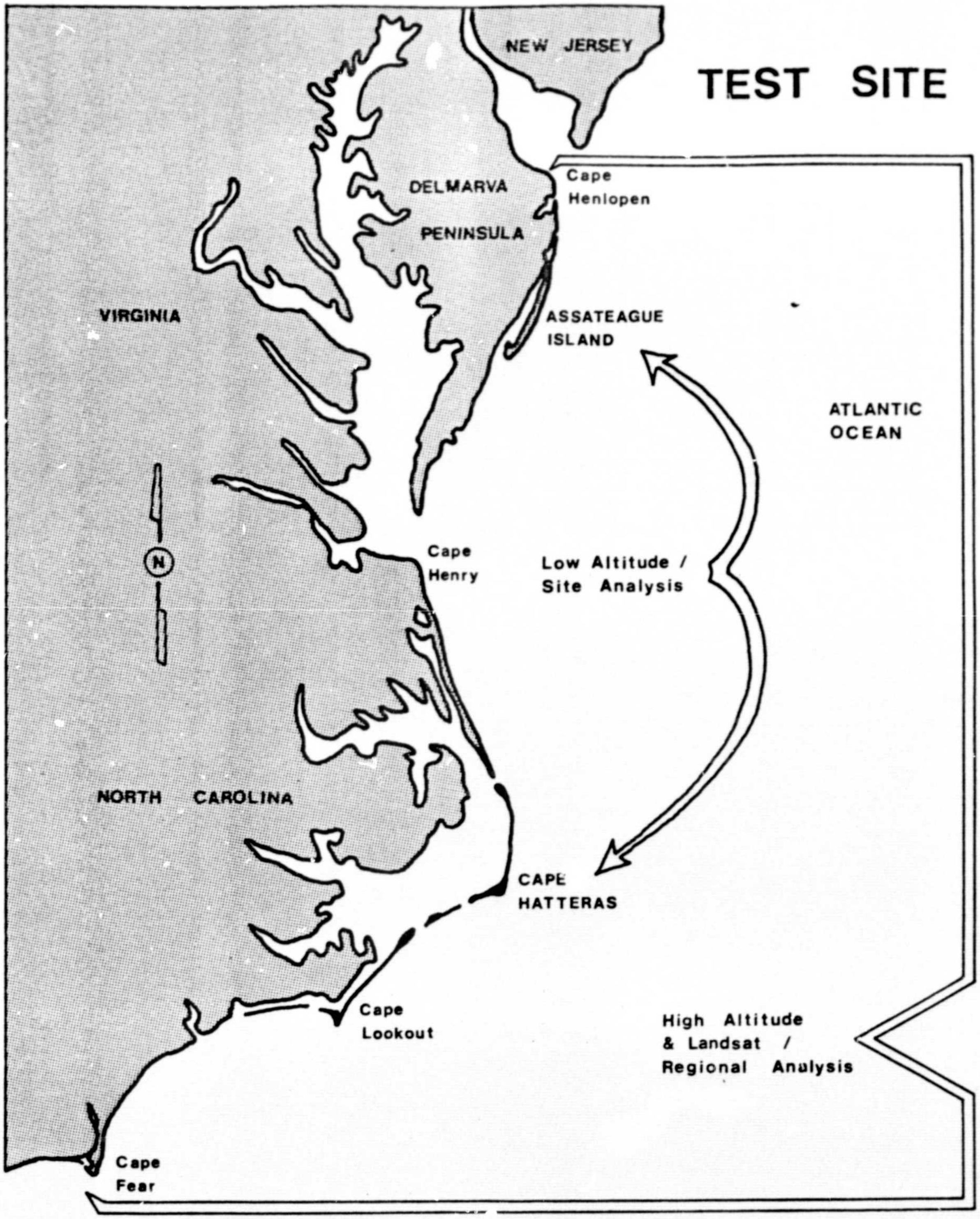


Figure 1: Barrier Islands of the Mid-Atlantic Coast.

HYPOTHESIS

Longshore variations in shoreline form occur as organized patterns with features or curvatures ranging in scale from beach cusps to very large shoreline meanders. Crescentic coastal landforms are dynamic and respond readily to varying sea state, tides, and sea level. The smaller ones appear, disappear, and migrate along the shoreline, and the larger features establish the spatial context for along-the-shore distribution of erosion and storm overwash processes. The landforms include: (1) small cusps, or cusplets, only a meter across, (2) beach cusps which are up to tens of meters in length, (3) giant beach cusps, or shoreline sand waves, from 100 to 3,000 meters in length, (4) secondary capes 25 to 50 kilometers apart, and (5) capes 100 to 200 kilometers apart. Groupings 3 and 4 are in the mesoscale range.

If the large scale crescentic coastal landforms are associated in time and space with inshore processes of similar scale, then it is reasonable to assume that there should be a measurable relationship between the spatial distribution of shoreline forms and manifestations of shoreline dynamics (Figure 2). Our investigation is designed to test if there is a significant correlation between coastal erosion and orientation of relatively straight shoreline segments within larger sinuous features.

Our investigation is based on the interpretation of imagery of Assateague Island from Ocean City Inlet to Chincoteague Inlet and North Carolina Outer Banks from Nags Head to Ocracoke Inlet at three different scales: low-altitutde metric photography at scales ranging from 1:5,000 to 1:40,000; high-altitude metric photography at 1:120,000; and Landsat II imagery enlarged to 1:80,000 and 1:250,000.

HYPOTHESIS :

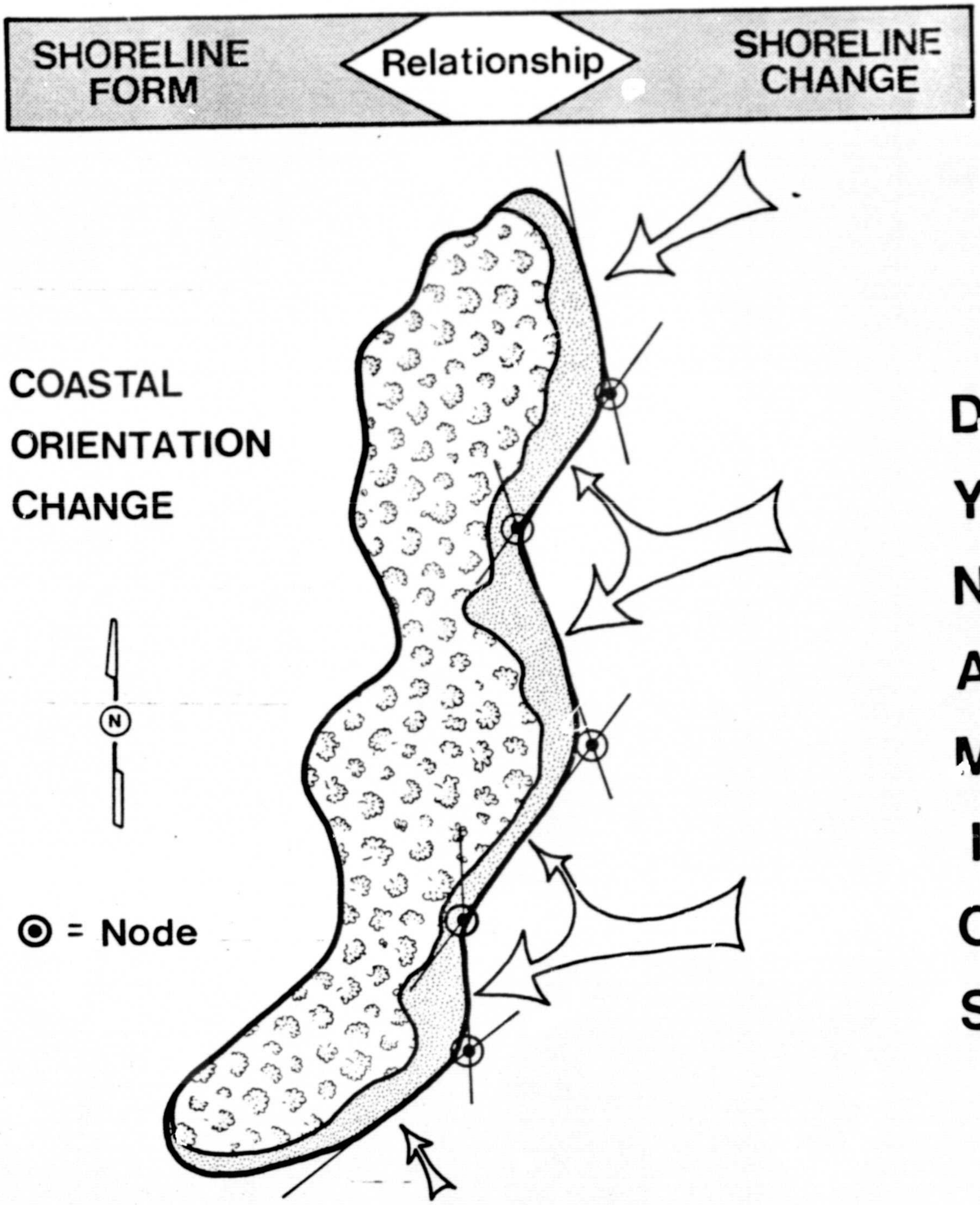


Figure 2: Shoreline Form and Shoreline Dynamics.

MEASURING HISTORICAL CHANGE

Since our concern is with monitoring change in coastal landforms and establishing shoreline dynamics through time, we developed a method which enables relatively rapid and accurate comparison of photographs taken of the same area at different times. The method, which was described in the quarterly report for the period 4/3/75 to 6/2/76 is reviewed here.

With varying scales of historical aerial photography and the need to measure relatively straight segments of otherwise curved shoreline, base maps at the scale of 1:5,000 were produced that divide the coastline into segments of 3.6 km. The base maps were drawn from enlarged sections of the most recent 7.5-minute series USGS topographic maps. The frame of each map is oriented with the long side parallel to the coastline and positioned over the barrier island so that the shoreline and vegetation line fit within the frame. The long side of the frame, lying entirely over the ocean, is the base line from which all measurements are made (Figure 3).

For each base map, we enlarged aerial photographs until the best possible fit of natural and cultural features between photo and base map was obtained. The shoreline and storm-overwash penetration line or vegetation line was then drawn on an overlay map. This process was repeated for each historical photograph of the same area.

The shoreline was defined as the high-water mark. The storm-overwash penetration line was defined by a smoothed line that separates the beach and dune sand or lightly vegetated sand flats from the relatively contiguous stands of dense vegetation. Alternatively, the grass line closest to the beach may be defined as the vegetation line.

An orthogonal grid system with transects spaced at 100-meter intervals along the coast was used to record to the nearest 5 meters the points at which the shoreline and the

METHOD OF DATA COLLECTION

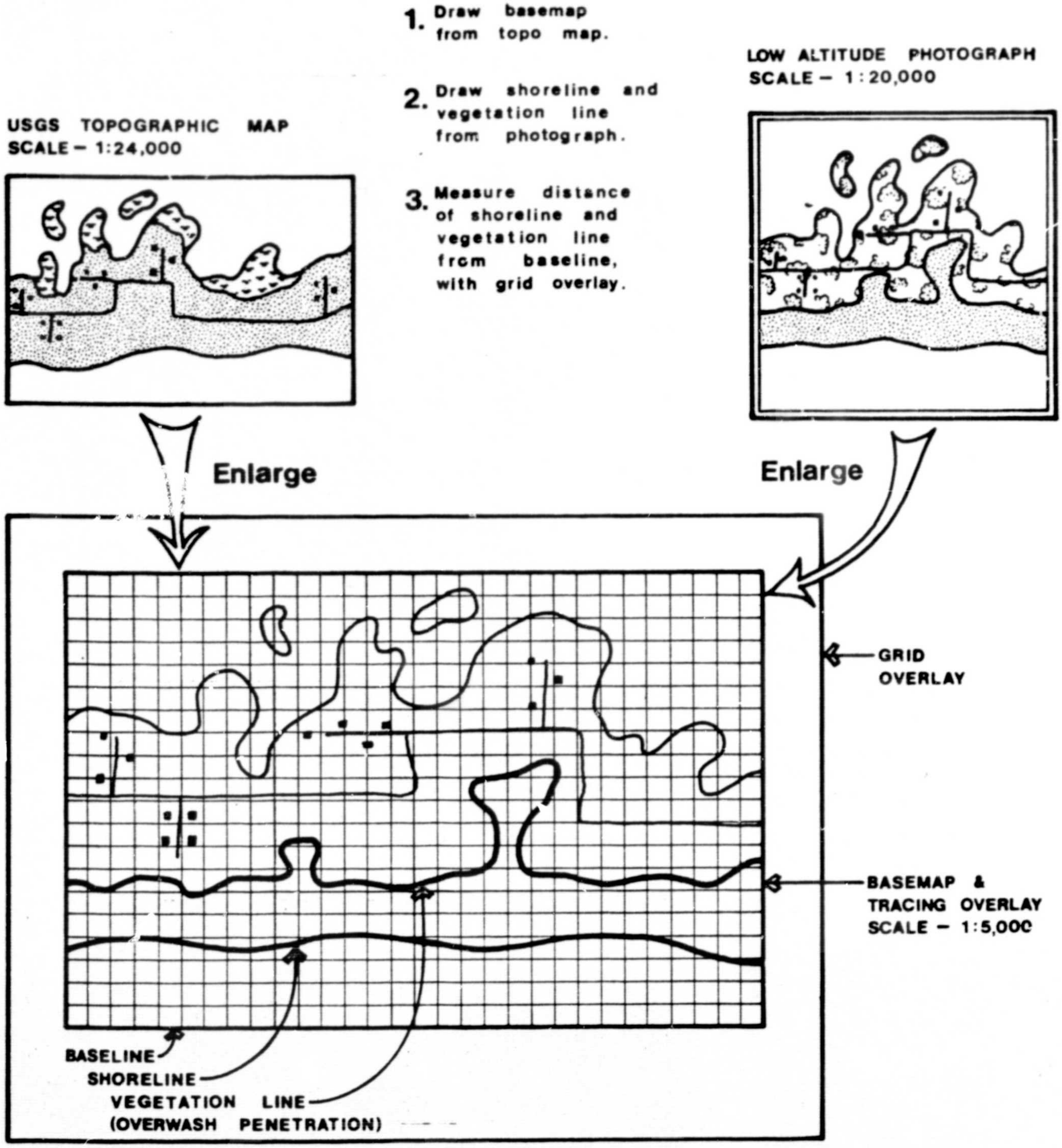


Figure 3: Method of Data Collection Using Historical Photography, Base Maps, and a Grid-Address System.

vegetation line intersected each across-the-shore transect. The information was then transferred to computer cards.

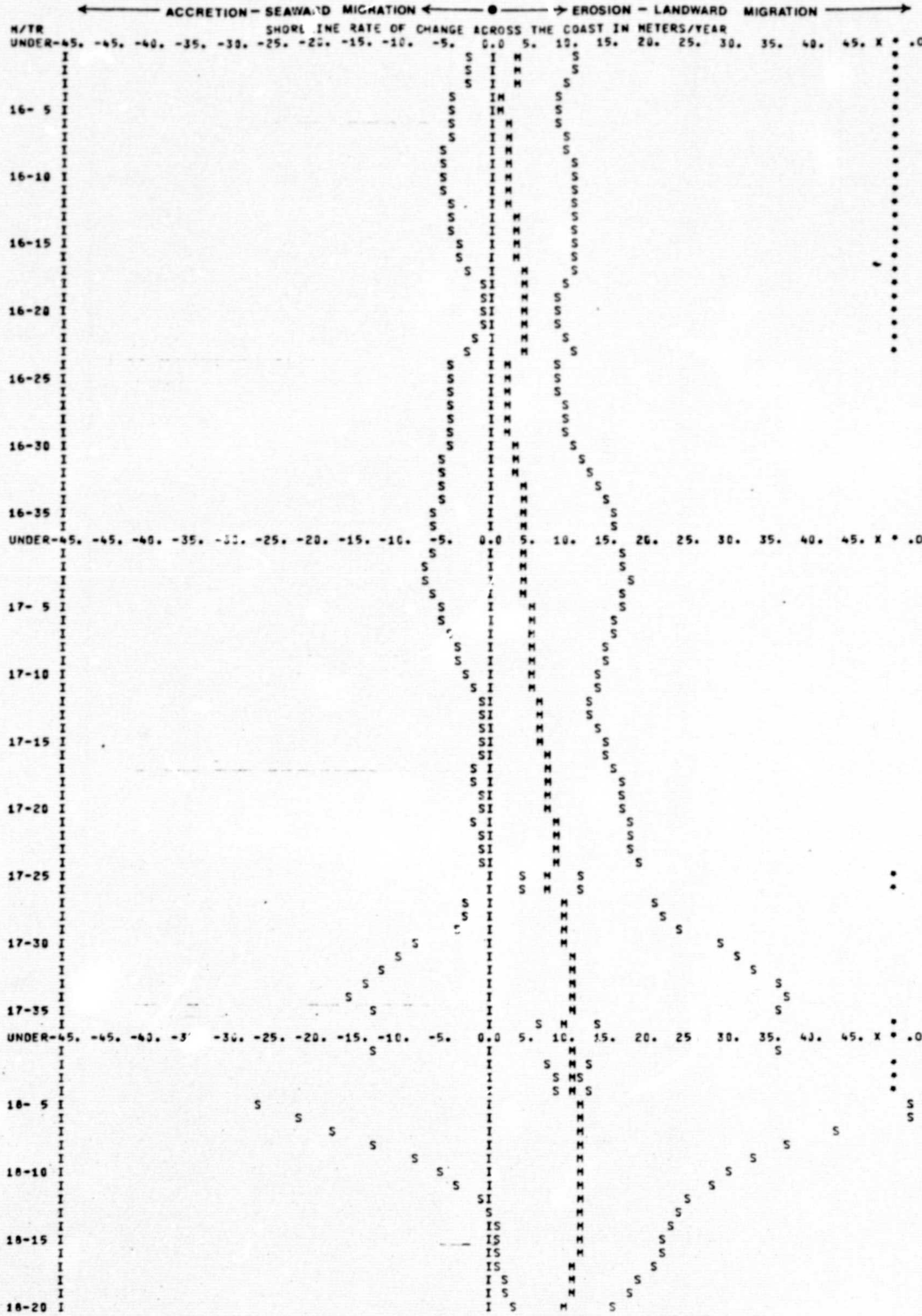
A computer program has been written which lists the following information for every base map (statistics include mean, variance, standard deviation, number of transects over which mean is calculated, maximum value, and minimum value).

1. Location of vegetation line (VL), shoreline (SL), and overwash-penetration distance (OP = VL - SL) for each of the 36 transects along the coast.
2. Line-printer graphs of VL, SL, and OP.
3. Changes and rates of change in VL, SL, and OP between selected dates (erosion and accretion statistics).
4. Line-printer graphs of rates of change in VL, SL, and OP.
5. Line-printer graphs of the mean + one standard deviation of rate of change in VL, SL, and OP (Figure 4).

In addition, the following information is provided for sections of the coast of any desired length:

1. Statistics on OP for each year and statistics on changes and rates of change in VL, SL, and OP between any two years.
2. Frequency distributions of OP for each year and of rates of change of VL, SL, and OP between any two years.

M = MEAN RATE OF CHANGE, FROM 02JUN38 TO 04JUN74 (36.00 YEARS).
S = ONE STANDARD DEVIATION FROM THE MEAN.
* = MEAN AND STANDARD DEVIATION WERE CALCULATED OVER A TOTAL TIME PERIOD LESS THAN 36.00 YEARS DUE TO ABSENCE OF DATA.
M/TR = MAP AND TRANSECT NUMBER. EACH TRANSECT REPRESENTS A DISTANCE OF 100 METERS ALONG THE COAST.



M/TR	MEAN	S.D.
	3.3	6.2
	3.3	6.4
	3.2	6.2
	1.2	6.6
16- 5	1.4	6.5
	1.5	6.9
	1.8	7.0
	1.9	7.5
	2.0	8.0
16-10	2.1	8.3
	2.2	8.1
	2.4	7.7
	2.6	7.6
	2.9	7.4
16-15	3.1	6.9
	3.3	5.9
	3.5	6.1
	3.7	5.0
	3.7	4.4
16-20	3.7	4.5
	3.7	4.5
	3.7	5.5
	3.7	6.3
	1.5	6.6
16-25	1.6	6.6
	1.7	6.6
	1.8	6.8
	2.1	7.2
	2.3	7.1
16-30	2.6	7.8
	2.8	8.4
	3.2	8.8
	3.6	9.5
	3.9	9.9
16-35	4.1	10.6
	4.2	11.2
.OVER 45		
	4.2	11.5
	4.2	12.1
	4.2	12.5
	4.4	11.6
17- 5	4.7	11.0
	4.9	10.6
	5.1	9.7
	5.2	9.1
	5.3	8.8
17-10	5.3	8.0
	5.4	7.2
	5.6	6.4
	5.8	6.6
	6.1	7.1
17-15	6.3	7.3
	6.5	7.6
	6.8	8.6
	6.9	8.8
	7.1	8.6
17-20	7.3	8.7
	7.6	9.2
	7.7	9.2
	7.9	9.2
	8.2	9.5
17-25	7.3	3.4
	7.4	3.5
	8.8	11.3
	8.9	11.9
	9.1	13.4
17-30	9.3	18.4
	9.5	20.6
	9.7	22.3
	9.8	25.2
	9.9	26.4
17-35	10.1	24.5
	9.4	3.4
.OVER 45		
	10.4	24.7
	9.5	2.3
	9.5	1.5
	9.9	1.8
18- 5	11.0	39.3
	11.1	34.5
	11.2	30.6
	11.4	25.0
	11.4	20.6
18-10	11.4	17.8
	11.4	15.3
	11.4	12.8
	11.3	11.4
	11.2	10.6
18-15	11.0	10.2
	10.7	10.1
	10.3	9.5
	10.0	8.2
	9.5	7.4
18-20	8.9	6.3

Figure 4: Computer Output of Historical Shoreline Change.

MEASURING SHORELINE FORM

To answer questions concerning the orientation and length of the shoreline segments within the larger crescentic forms, images of the coastline in the mesoscale range of 1:80,000 to 1:250,000 were needed. Landsat imagery is ideal for this purpose. Since our concern is with long stretches of coastline and large crescentic landforms, the relativey low resolution of the Landsat imagery was acceptable. The orthogonal accuracy of Landsat imagery and large area of coverage within a single frame rendered it more valuable than high altitude aerial photography.

By experimenting with various enlargements of the 70-mm Landsat negative transparencies, we were able to control the amount of "noise" one perceives in angular orientation along the coast. The method we are now using is simple, and it does not call for sophisticated equipment or digital processing of raw Landsat data. The steps are:

1. A photographic print is made from a 70-mm negative of Band 7 of a cloud-free Landsat image of the coastal area under study at a scale from 1:250,000 to 1:80,000.
2. A straight edge is placed along each straight-line segment of the coast as perceived by the mapper, and a line is drawn on an overlay. The point of intersection of adjacent lines is called a "node" and marks the location of change in angularity of the coastline (Figure 2).
3. Lengths of these line segments are measured and their angular orientations with respect to the north/south line are recorded in degrees north of south, or north of east.
4. Each node is located to the nearest 100-meter

transect previously defined in the discussion on historical data collection. The nodes then define the location of each straight-line segment along the coast.

A certain amount of subjectivity and user judgment is incorporated into this method; therefore, steps 2 through 4 representing one sample, were repeated a number of times to account for sampling error.

These data were then put into digital format compatible with the computer program written for the historical analysis, and mean values for segment length and orientation were calculated in the following manner. The length and orientation of each straight-line segment was assigned to each transect within that segment and the mean values of length and orientation for each transect, measured over all samples, were calculated. Each transect, representing a 100-meter segment of coast, had a slightly different mean orientation from adjacent transects. There were therefore as many straight-line segments as there were transects--more than five hundred for Assateague Island. When we compared orientation and erosion on a transect-by-transect basis, correlation coefficients seldom exceeded .6. However, our hypothesis states that it is the mesoscale rather than small scale features that reflect the long-term effects of coastal dynamics. Thus if the number of straight line segments is reduced, the correlations between orientation and erosion should increase.

Our computer program is designed to perform this segment reduction or smoothing process automatically, based on a threshold of change in angular orientation. For example, if we assign a threshold value of 1°, the program will divide the island into segments whose change in angular orientation from one segment to the next is at least 1°. The program begins at one end of the island with the first transect, and adds

changes in orientation until the algebraic sum exceeds 1°. That particular transect marks the end of the new first segment, the length of which is easily calculated and the orientation of which is the mean of the orientations of the transects within the segment. The process is repeated to determine the length and orientation of the second segment, and on until the end of the island is reached.

The threshold is then increased by 1°, and the entire process is repeated to define a new set of segments. This is repeated, each time with an increased threshold, until the island is divided into three segments, the minimum number allowed in order to run a regression analysis with N-2 degrees of freedom. The smaller the initial threshold, the greater the number of initial segments and the greater the number of repetitions before three segments are reached.

REGRESSION ANALYSIS

For each repetition at a given threshold value, we ran regression and correlation analyses between pairs of expressions for shoreline form and shoreline dynamics which are summarized below (see also Figure 5).

A = angular orientation of segment in degrees North of East.

B = length of segment in meters.

C = mean rate of erosion over entire segment in meters/year.

D = mean standard deviation of rate of erosion in meters/year.

E = average of the mean plus one standard deviation of rate of erosion in meters/year.

Independent Variable	Dependent Variable B	C	D	E
A	x	x	x	x
B		x	x	x
C			x	

The analysis includes the correlation coefficient (r), the significance of r (s), the standard error of estimate of r (e), scatterplots, and the regression line. We used the scatterplots to analyze the data for locating stray points, and for discovering multiple populations and non-linear relationships.

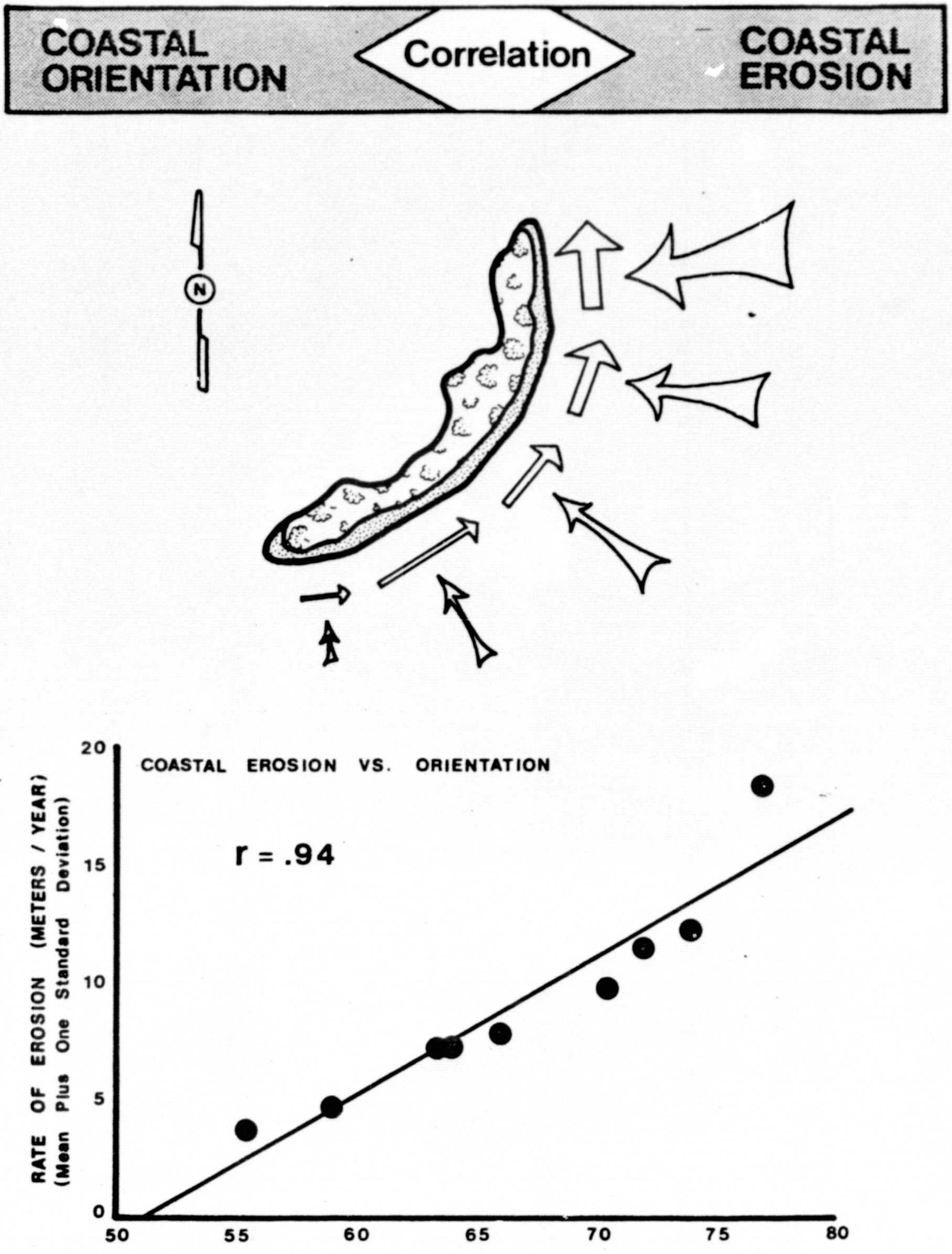


Figure 5: Analysis of Coastal Orientation vs. Coastal Erosion.

SIGNIFICANT RESULTS

We applied the previously described methods to Assateague Island from Ocean City Inlet to the southeast end of the island over a distance of 55 kilometers. Seven sets of aerial photography - June-1938, May-1949, March-1955, October-1959, April-1961, December-1962, and June-1974 - were used to establish rates of erosion. Five samples of shoreline orientation were used to produce the set of mean transect-segments. The southern one kilometer and northern 1.7 kilometers of the island were not included due to obvious anomalistic effects of the adjacent inlets. A Landsat enlargement to 1:80,000 was used.

The results of our correlation analysis are shown in Table 1 for angular orientation of coastal segments in degrees north of east vs. the mean standard deviation of rate of erosion of the segments in meters per year. It is the most important pairing related to our hypothesis, because the standard deviation of rate of erosion best represents the variable nature of coastal dynamics. The graph in Figure 6-A shows the relationship between r and the number of coastal segments.

If we examine the scatterplot of the regression analysis for the threshold of 1.0° (36 segments), we see that three points are obviously outside of the dominant field (Figure 7). These points represent three short segments in the northern .7 km of the island and reflect the influence of Ocean City Inlet. Scatterplots at the other thresholds exhibit similar stray points, all of which represent segments within 1.3 km of the northern end of our study site and which are thus influenced by the inlet. Therefore, we reran the correlations with these segments omitted. The results are summarized in Table 2 and Figure 6-B.

All of the correlation coefficients increased, most by more than 20 percent. The highest r's (greater than .9) that were significant at the 1 percent level occurred when the change

TABLE 1. CORRELATION STATISTICS BEFORE REMOVAL OF ANOMALISTIC SEGMENTS

CORRELATION STATISTICS FOR SHORELINE FORM VS. COASTAL DYNAMICS FOR ASSATEAGUE ISLAND

Angular Orientation (Degrees North of East)
x Standard Deviation of Rate of Erosion (Meters/Year)

	Orientation Change Threshold	Number of Segments	Mean Segment Length	Correlation Coefficient (r)	Significance of r (s)	Standard Error of Estimate of r (e)
**	.5°	59	.9km	.69	.00001	3.5
**	1.0	36	1.5	.64	.00001	3.9
**	1.5	27	2.0	.65	.00014	3.7
**	2.0	19	2.9	.64	.00168	4.1
**	2.5	15	3.7	.64	.00509	3.6
**	3.0	15	3.7	.71	.00160	3.4
**	3.5	11	5.0	.69	.00999	3.5
*	4.0	9	6.1	.63	.03453	3.9
*	4.5	9	6.1	.63	.03321	4.3
	5.0	7	7.9	.58	.08536	4.4
*	5.5	5	11.1	.92	.01291	1.3
*	6.0	3	18.4	.99	.04161	0.6
*	6.5	5	11.1	.92	.01247	1.4
	7.0	3	18.4	.97	.08314	1.2
	7.5	3	18.4	.97	.08134	1.2
	8.0	3	18.4	.96	.09389	1.5

** Significant at the 1% level.

* Significant at the 5% level.

TABLE 2. CORRELATION STATISTICS AFTER REMOVAL OF ANOMALISTIC SEGMENTS

CORRELATION STATISTICS FOR SHORELINE FORM VS. COASTAL DYNAMICS FOR ASSATEAGUE ISLAND

Angular Orientation (Degrees North of East)
x Standard Deviation of Rate of Erosion (Meters/Year)

Orientation Change Threshold	Number of Segments	Mean Segment Length	Correlation Coefficient (r)	Significance of r (s)	Standard Error of Estimate of r (e)
** .5°	55	1.0km	.80	.00001	2.0
** 1.0	33	1.7	.80	.00001	1.9
** 1.5	25	2.2	.84	.00001	1.7
** 2.0	17	3.3	.86	.00001	1.6
** 2.5	14	3.9	.84	.00009	1.8
** 3.0	15	3.7	.75	.00057	2.9
** 3.5	10	5.5	.90	.00022	1.5
** 4.0	8	6.9	.92	.00054	1.4
** 4.5	8	6.9	.93	.00036	1.4
** 5.0	6	9.2	.93	.00364	1.5
* 5.5	5	11.1	.92	.01330	1.3
6.0	3	18.4	.99	.05143	0.7
* 6.5	5	11.1	.92	.01290	1.4
7.0	3	18.4	.97	.08314	1.2
7.5	3	18.4	.97	.08134	1.2
8.0	3	18.4	.96	.09389	1.5

** Significant at the 1% level.

* Significant at the 5% level.

r = Correlation Coefficient for Coastal Orientation vs. Coastal Erosion

⊙ = r is Significant at 1 % Level

X = r is Significant at 5 % Level

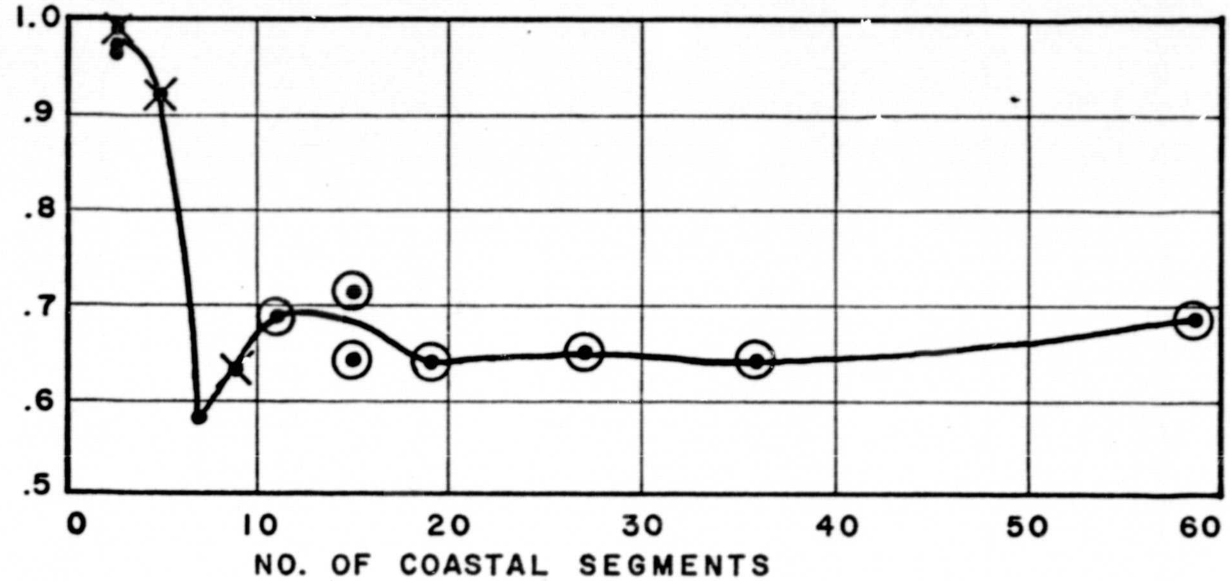


FIGURE 6-A: r vs. Number of Coastal Segments for Assateague Is. Before Removal of Anomalistic Segments

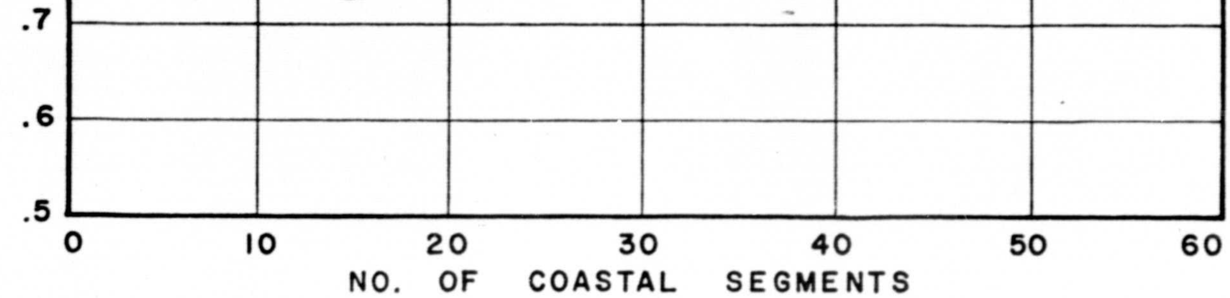


FIGURE 6-B: r vs. Number of Coastal Segments for Assateague Is. After Removal of Anomalistic Segments

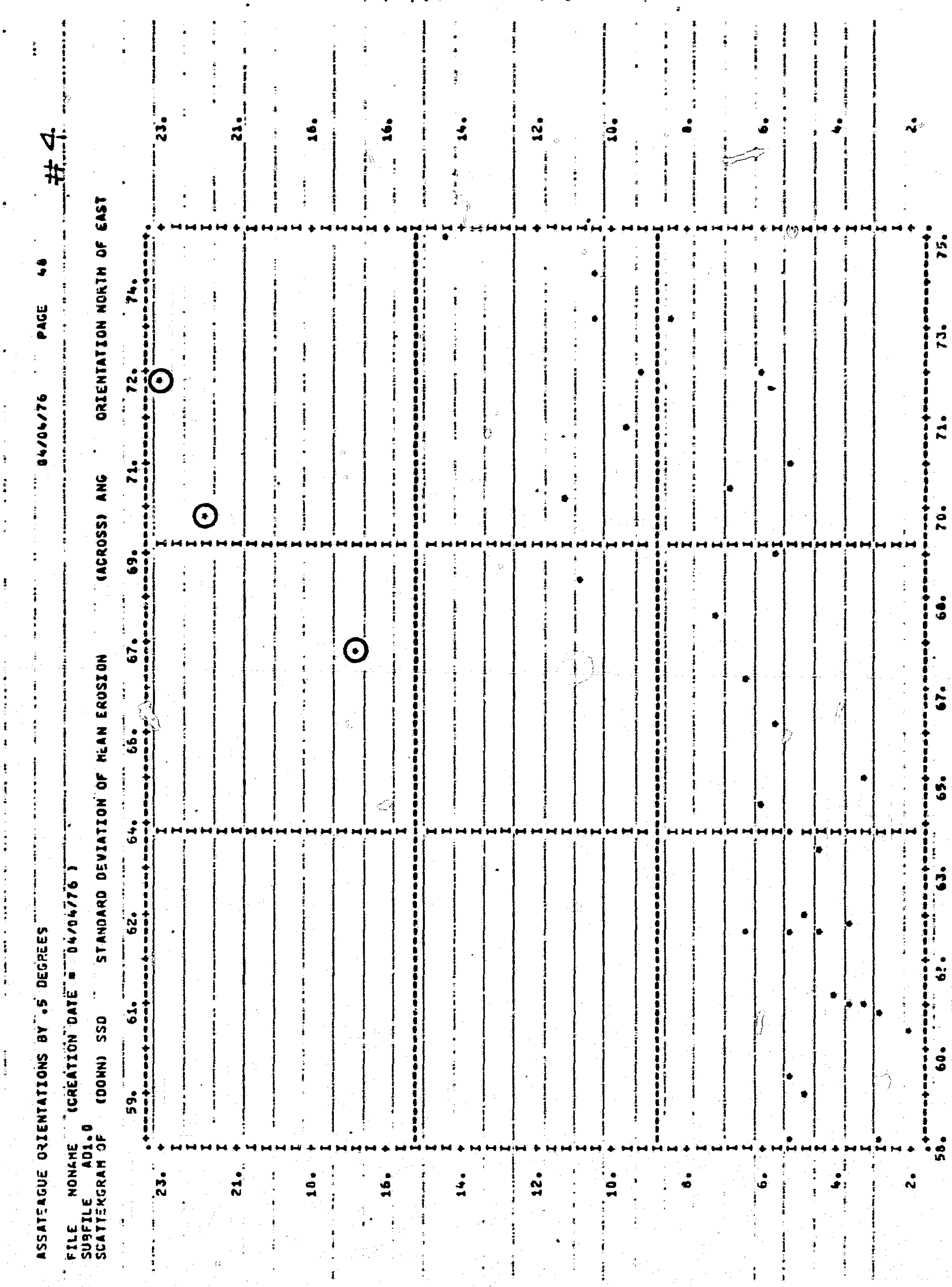


Figure 7: Scatterplot of Coastal Orientation (degrees) vs. Coastal Erosion (m/yr) for 36 Segments of Assateague Island.

in orientation thresholds produced between five and ten coastal segments in the mesoscale range of 5 km to 10 km per segment. It is interesting to note that in 4 previous samples of drawing coastal segments on a Landsat image enlarged to 1:250,000 we had defined an average of 9.5 segments.

These results support our hypothesis that shoreline form is highly correlated with coastal dynamics, especially in the mesoscale range. Specifically, the orientation of relatively straight-line segments of the coast of Assateague Island when measured in the mesoscale range of 5 to 10 kilometers, is significantly correlated with erosion. As the orientation of the coast approaches north-south, the standard deviation or rate of erosion increases.

PROBLEMS

The absence of any major storms occurring within our study area during the 1975/76 storm season has made it difficult to test our capability of predicting locations of major storm impact. The largest storm occurred during the first week in March, and it may not have been of sufficient intensity to have caused significant changes in the shoreline and overwash zones. However, low altitude aerial photography flown by NASA-Wallops on 19 February and 14 March has been ordered to measure any changes that did occur. Results of these measurements will be presented in a later quarterly report.

CONCLUSIONS

In the mesoscale range of 1:80,000 to 1:250,000, there is a highly significant (1 percent level) positive correlation (> .9) between the orientation (with respect to an imaginary north-south line) of straight-line segments of the coast as measured from Landsat imagery, and the mean standard deviation of rate of erosion of those segments on Assateague Island.

As the orientation of any segment of the Assateague coast (excluding the northern two km and southern one km of the island) approaches north-south, extremes in coastal erosion and storm surge penetration caused by major storm events have increased in the past, and will probably continue to do so in the future.

At the point of intersection of two adjacent segments (turning point in the coast), if the point is seaward such as in a false cape situation, the northern segment is more vulnerable to storm damage than the southern one; if the point is landward such as in an embayment situation, the southern segment is more vulnerable to storm damage.

The above responses to coastal dynamics can be explained by the fact that the major storm forces that strike the coast of Assateague Island arrive from a northeasterly direction.

By measuring coastal orientation, it is possible to determine solely from a recent Landsat image of Assateague Island at scales from 1:80,000 to 1:250,000 those sections of the coast which have historically proven to be most dynamic and most vulnerable to storm damage. Therefore, it is possible to predict those areas that will be most vulnerable to future storms by the same procedure.

Through continuous monitoring of Assateague Island with Landsat imagery, it should be possible to detect changes in orientation and associated changes in expected relative vulnerability to storm damage along the island.

Similar relationships between shoreline form and coastal dynamics should exist for all sedimentary coasts along the Atlantic seaboard that fall within dynamic regimes similar to that of Assateague Island.

RECOMMENDATIONS

Most of our conclusions to date have been restricted to Assateague Island. We cannot be certain that the same process-response relationships hold for other barrier islands. Accordingly, we wish to extend our studies to include Cape Hatteras, Cape Lookout, and the New Jersey coast. Hatteras data has been collected and is now being analyzed. However, the entire process of data acquisition, including imagery search and base map preparation, must be initiated for Cape Lookout and New Jersey.

A six-week field investigation is being planned to collect on-site data such as beach slope and sand grain size distribution at numerous locations on Assateague and Hatteras. Locations for sampling will coincide with transects previously established for historical data collection. Transects will be randomly chosen in proportion to the length of shoreline segments as defined from Landsat imagery in our regression analyses. This data will then be correlated with existing shoreline form and dynamics data.

Our analysis to date has been confined to the shoreline. We have at hand equally extensive data on changes in the vegetation line and the zone of overwash and storm surge penetration. We hope to analyze this data using techniques similar to those which we developed for studying the shoreline.

In order to provide the time and funds to continue with the above research, we have recommended that our NASA grant be extended an additional two years. At the time of writing this report, it appears that the funding will be approved.

LANDSAT USER BENEFITS

Landsat images provide the viewer with excellent single-frame perspectives of regional land masses. Where mapping of regional boundaries is concerned, especially for land-sea interfaces as seen in MSS band 7, the accuracy of Landsat with respect to radial displacement and spatial distortion is superior to that of aerial photography. As Landsat enlargements approach 1:80,000, the poor resolution of site-specific features is apparent, and "noise" becomes a problem in image interpretation. Therefore, simple mechanical measurements from Landsat imagery should be confined to those features large enough to be measured in terms of kilometers. Features up to 10-15 kilometers in size can be viewed and measured with more accuracy with high altitude aerial photography (1:120,000). Low altitude aerial photography (1:20,000) is best used for features ranging in size from a few meters to one or two kilometers.

We have shown in this paper how Landsat can be used to define those segments of the coast of Assateague which have a higher probability of being vulnerable to storm damage than others. We hope to show that this same method can be applied to other sedimentary coasts with equal success.

Potential users of this application of Landsat imagery include any agency responsible for the management of or interested in studies in the coastal zone such as: the National Park Service; U.S. Fish and Wildlife Service; U.S. Geological Survey; various state geological surveys; state, county, and community planning agencies; the Department of the Navy; private land developers of industrial, commercial, recreational, and residential property; universities and other institutions conducting coastal studies research, such as University of Massachusetts, North Carolina State University, Louisiana State University, Virginia Institute of Marine Science and many others.

We have designed a graphic presentation consisting of slides and large-scale diagrams that describe the methods and results reviewed in this report. Presentations have been made to administrative officials of Assateague National Seashore, Assateague Maryland State Park, Cape Hatteras National Seashore; scientists at Louisiana State University; officials of the National Park Service and U.S. Geological Survey in Washington, D.C., and students in environmental sciences at the University of Virginia. Other presentations are planned in the future, including one to a group of Delaware/Maryland coastal researchers in Ocean City, Maryland, on 29 April.

The system we have developed to study the mid-Atlantic coasts is based on three levels of remote sensing of which Landsat is a necessary element. We have defined a use for which Landsat is ideally and uniquely suited; but its value lies in the fact that is provides a new visual dimension that should be used in conjunction with, and which cannot be replaced by other forms of remote sensing.

PROGRAM FOR NEXT REPORTING INTERVAL

Analysis of relationships between shoreline form and coastal dynamics will be extended to data already gathered for Cape Hatteras, North Carolina, from Nags Head to Ocracoke Inlet. We will be able to determine if conclusions derived from the Assateague studies will also hold true for Hatteras. When we receive the low altitude imagery bracketing the recent March storm, we will measure shoreline change and overwash penetration and test our ability to predict locations of storm vulnerability based on historic data. On-site data collection at Assateague and Cape Hatteras is scheduled to begin in May and last for six weeks.

PUBLICATIONS

A paper describing our methods of shoreline data collection using aerial photography and Landsat imagery, and preliminary results of correlative analysis between shoreline form and coastal dynamics, was presented at the Symposium on Research Techniques in Coastal Environments on 18 March 1976, at Louisiana State University in Baton Rouge, Louisiana. The paper will be included in a forthcoming volume in the Geosciences and Man series published by the School of Geosciences, LSU.

FUNDS EXPENDED

The total budget allotted 3 April 1975, was $41,000. As of 31 March 1976, expenditures were $29,330, or 72 percent. A balance of $11,670 remains for the duration of this phase of the project, which ends 2 June 1976. This balance is totally encumbered with a deficit of $700.

DATA USE

Total funds allotted for Landsat imagery were $1,700. Expenditures as of 31 January 1976 were $850, or 50 percent, leaving a balance of $850.

Most of the imagery is in 70 mm negative transparency format. We use in-house processing facilities to enlarge selected frames of MSS Band 7 to 9" x 9" prints. Measurements are made on selected frames which we enlarge to scales of 1:250,000 and 1:80,000.

AIRCRAFT DATA

Total funds allotted for high altitude U-2 imagery ordered through Sioux Falls amounted to $1,044. A set of 72 color infrared prints covering our study site at a cost of $252 was shipped to us on 1 October 1975. The balance of 31 March 1976 was $792.

Mosaics have been made of the photographs and serve as a valuable visual aid in our analysis. On 30 March 1976, we placed an order through Sioux Falls for imagery from Flight #76-023, Accession #02299. This order has not yet been received.